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(54) **STARTER FOR A POWER TOOL WITH IMPROVED KINEMATICS**

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F02N 3/02 (2006.01)

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CPC ... ***F02N 3/02*** (2013.01); ***F02N 1/00*** (2013.01)

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USPC 123/185.1–185.13
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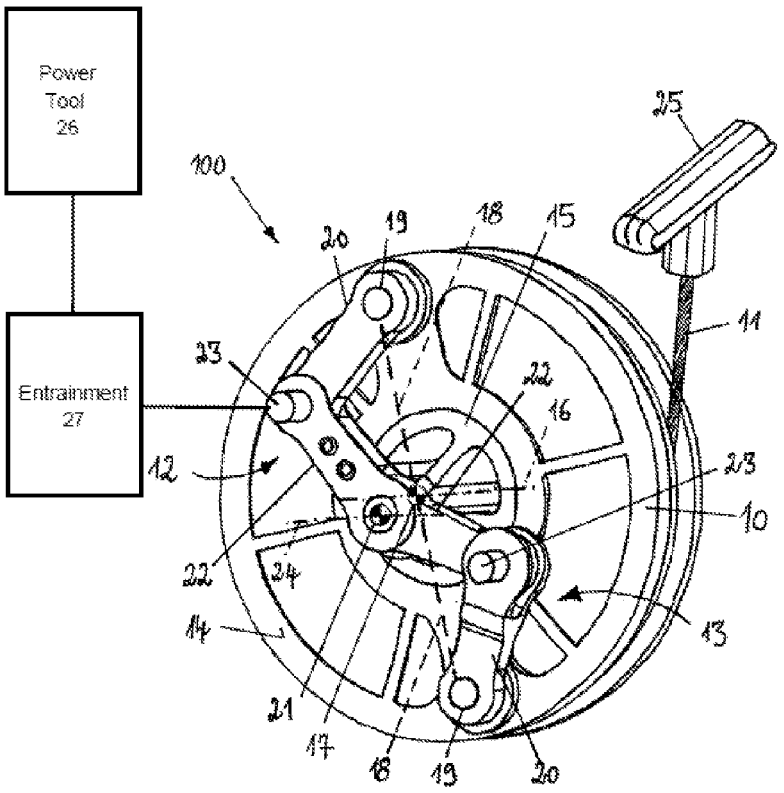
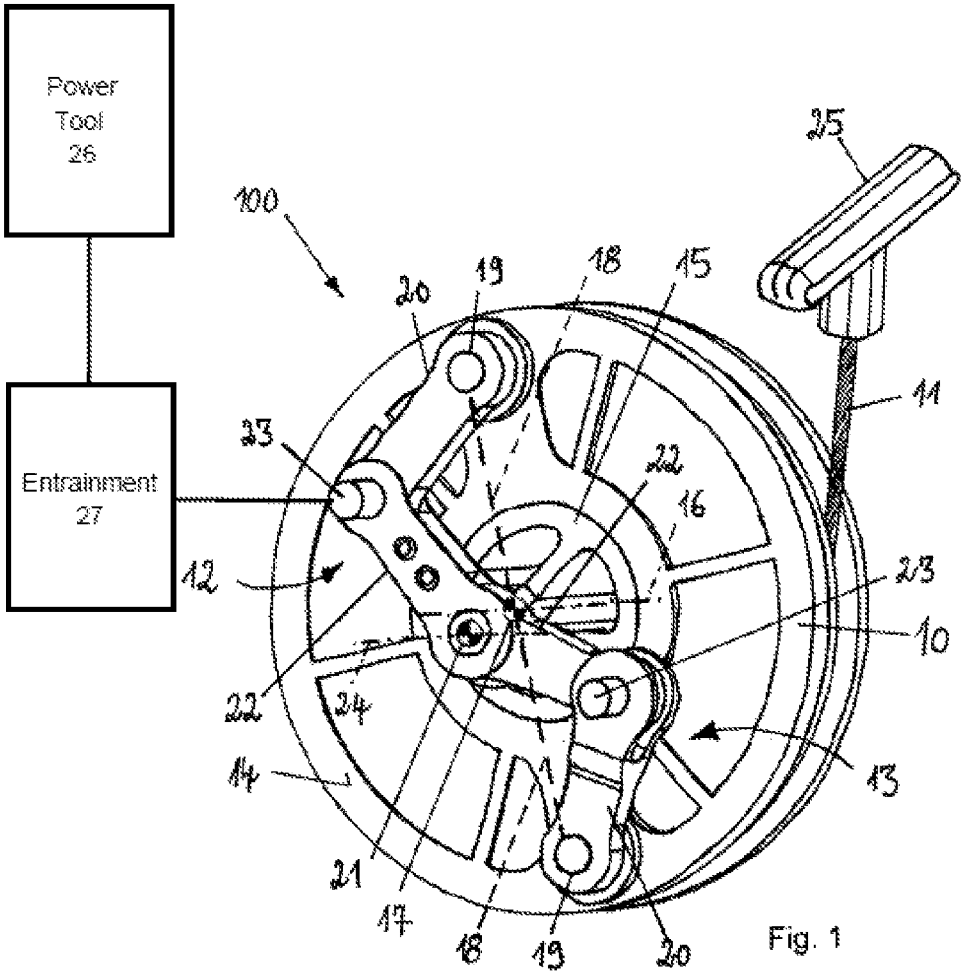
(57) **ABSTRACT**

Starter for starting a combustion motor for a power tool includes a rotating tension means roller, onto which a tension means can be wound and which via active connection is connected to a entrainment means of the combustion motor in order to introduce a rotating movement into the combustion motor. The active connection has at least one double crank gear between the tension means roller and the entrainment means.

13 Claims, 2 Drawing Sheets




Power
Tool
26
Entrainment
27
100
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16
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20
15

Fig. 1

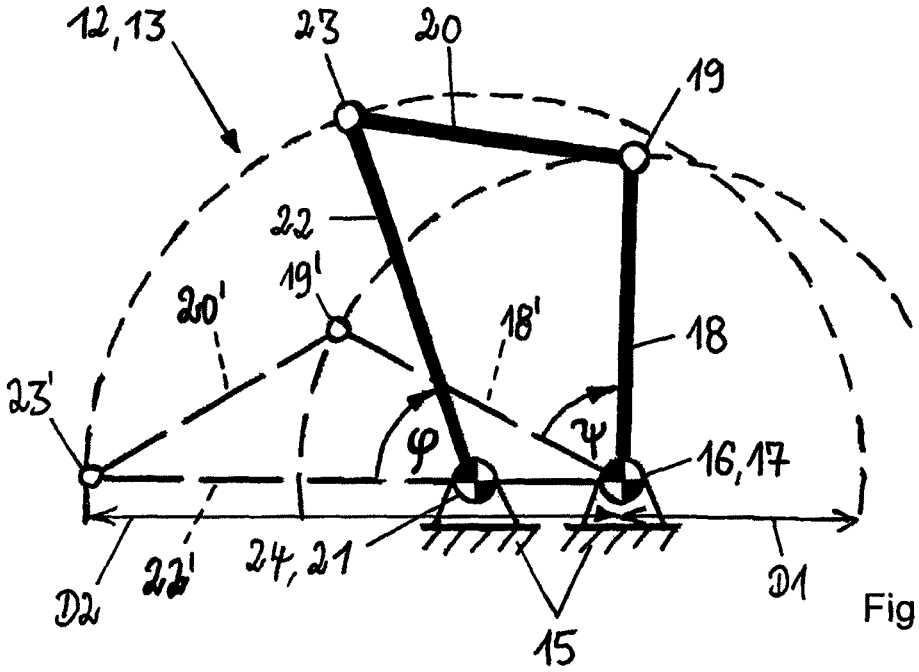
12,13
23
20
19
22
19'
20'
18'
18
23'
φ
ψ
16,17
D2
22'
24,21
D1
15

Fig. 2

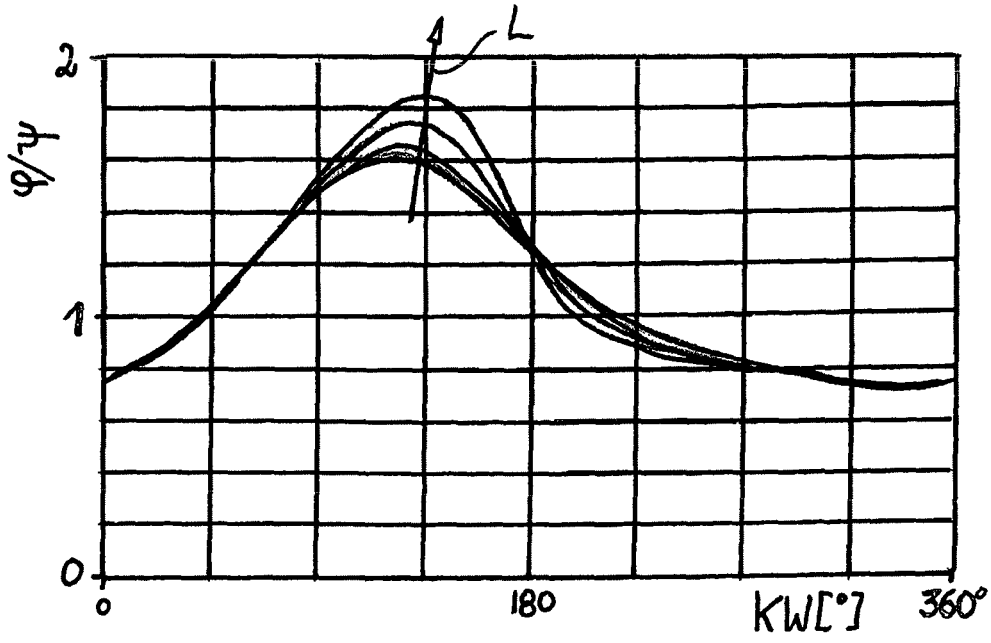
L
2
φ/ψ
1
0
0
180
KW[°]
360°

Fig. 3

STARTER FOR A POWER TOOL WITH IMPROVED KINEMATICS

The present invention relates to a starter for starting a combustion motor, more particularly for a power tool with a rotating tension means roller, onto which a tension means can be wound and which via an active connection is connected with an entrainment means of the combustion motor in order to introduce a rotating movement into the combustion motor.

PRIOR ART

From DE 10 2008 021 196 A1 a starter for starting a combustion motor of a power tool is known and a rotating tension means roller is shown onto which a tension means can be wound and which via an active connection is connected to a drive plate of the combustion motor in order to introduce a rotating movement into the combustion motor.

At the end of the tension means there is a grip and at the grip a tensile force can be introduced into the tension means in order to start the combustion motor.

By way of an active connection with the drive plate the rotating movement is transmitted to the combustion motor and the drive plate performs at least the same rotating movement as the crankshaft of the combustion motor. Due to the design of the combustion motor the crank shaft has a torque band which periodically changes over the full rotation of the crankshaft. During the compression phase of the combustion motor a high torque is required which has to be transmitted to the crankshaft in order initiate its rotating movement. During the expansion phase, on the other hand, the crankshaft only requires a small toque or no torque, as through the expansion of the gas in the combustion chamber of the combustion motor a gas spring effect is produced so that the crankshaft is turned by itself. This strong period torque band of the combustion motor to be started generates a corresponding increasing and decreasing force in the tension means which the user must expend and perceives as a jerky, pulsating loading.

In order to dampen the force peaks produced by the period torque band in the tension means, a deformation element is proposed in the active connection between the tension means roller and the drive plant, in which lagging or racing of the crankshaft of the tension means roller can be evened out. In this way the force peaks are reduced, resulting in increased operating comfort of the start and therefore of the power tool.

From DE 10 2008 021 197 A1 a further starter for starting a combustion motor is known, and the active connection between the tension means roller and an entrainment means comprises a coupling rod which interacts with a lever arm. This results in an active connection between the tension means roller and the entrainment means, which brings about a different angle between the tension means roller and the entrainment means. Disadvantageous, however, is the fact that a further coupling element is required for coupling the starter to the entrainment means. Once the combustion motor has started it must be uncoupled from the starter for which latch elements must be arranged on the entrainment means which engage in the coupling element when the starter is activated and the combustion motor has not yet started.

Here, it can occur that the latch element can only engage in the coupling element after almost a complete rotation of the tension means roller. This results in a drawback for operating the starter, as a considerable length of the tension means first has to be unwound from the tension means roller in order to achieve engagement of the latch elements of the entrainment means in the coupling element.

In accordance with one form of embodiment the problem of the maximum required turning angle is solved in that two joint socket geometries are provided in a position 180° opposite each other on the tension means roller, but with the drawback that this design does not work satisfactorily in practice. In addition, the pole wheel has a coupling element that differs from a widely used conventional standard. In a conventional pole wheel latches are used. This means that two different pole wheels have to be provided, depending on which type of starter is being built. As an additional disadvantage the centrifugal element must engage in a drive lying eccentric to the pole wheel. Over a rotation of the pole wheel this results in asymmetrical behaviour of the engagement of the centrifugal element.

It is therefore the objective of the present invention to create a starter for starting a combustion motor which overcomes the disadvantages of the above prior art and can even out changeable torque between the tension means roller and the combustion motor, whereby, more particularly a starter is to be created which allows active connection between the tension means roller and the entrainment means of the combustion motor after considerably less than a full rotation of the tension means roller.

This objective is achieved in the basis of a starter for a power tool in accordance with the introductory section of claim **1** in conjunction with the characterising features. Advantageous further developments of the invention are set out in the dependent claims.

DISCLOSURE OF THE INVENTION

The invention includes the technical teaching that the active connection between the tension means roller and the entrainment means has at least one double crank gear.

Double crank gears belong to the group of four-joint coupling gears, so that the gear has four coupling elements, with the coupling elements being connected to each other by means of joints. More particularly, two joint points can be designed as joint points fixed on the housing, so that between the fixed housing joint point the coupling element can be dispensed with. Consequently, double crank gears have a drive element, a output member and a coupling element, and the coupling element extends between the free ends of the drive element and of the output member. The drive element is rotatably borne in a first joint point and the output member is rotatably borne in a second joint point, and when the drive element is rotated about the first joint point the output member performs a rotating movement about the second joint point which results in an angle displacement between the drive element and the output member over the full rotation of the elements.

A particular advantage is achieved if the active connection between the tension means roller and the entrainment means has at least two double crank gears. This results in the advantage that the tension means roller does not have to complete a full rotation in order to achieve engagement of the entrainment means with the tension means roller, and if a second double crank gear is arranged between the tension means roller and the entrainment means an active connection between the tension means roller and the entrainment means can come about after a maximum rotation of the tension means roller of 180°. For example the tension means roller can have a diameter of 70 mm so that there is a maximum tension length of the tension means of 100 mm until the active connection of the tension means roller engages with the entrainment means of the combustion motor.

In accordance with an advantageous form of embodiment, the tension means roller has a flat side, whereby the at least one double crank gear is arranged on the flat side of the tension means roller. The tension means roller can be in the form of a disk and the double crank gear is dimensioned so that the double crank gear can be arranged on the flat side of the tension means roller. If, in accordance with the invention, two double crank gears are envisaged, both double crank gears are arranged on the tension means roller.

More particularly, two double crank gears can be arranged in a position offset by 180° with regard to each other on the flat side of the tension means roller, whereby in an arrangement of more than two double crank gears an even distribution about the circumference of the tension means roller is envisaged.

Through the arrangement of two more double crank gears between the tension means roller and the entrainment means the components of a double crank gears with the corresponding elements, more particularly with the den drive elements, the output member and the coupling elements are all present in double or multiple form. Through, for example, a double, 180° offset arrangement of the double crank gears the engagement of the entrainment means with the tension means roller through the active connection takes place after a rotation of the tension means roller by around 180° at the latest. In the case of a triple arrangement of double crank gears the required rotation of the tension means roller can be reduced to around 120°, whereby with a further increase in the number of double crank gears this results in a further reduction in the required rotation of the tension means roller.

In accordance with a preferred form of embodiment a roller holder element is provided with an axis of rotation that is fixed and more particularly rigidly arranged in the structure of the power tool. On the roller holder element the tension means roller can be held rotatably about the axis of rotation and the roller holder element forms a resting first joint point of the at least one double crank gear which lies in the axis of rotation of the tension means roller. The roller holder element can, for example, be cylindrical in form and rotatably borne on the lateral surface of which is the tension means roller, which has a centrally bored hole, through which the roller holder element extends. The roller holder element can form the resting first joint for both double crank gears arranged on the tension means roller, so that first resting joint point of both double crank gears lie in each other.

The double crank gear is designed and arranged on the tension means roller so that the tension means roller forms a drive element of the at least one double crank gear, whereby arranged on the tension means roller at a distance from the axis of rotation there is at least one joint element, on which one end of a coupling element of the double crank gears arranged in an articulated manner. Furthermore, the roller holder element, on which tension means roller is rotatably held, has a resting second joint of the at least one double crank gear, which lies at a distance from the axis of rotation of the tension means roller and which is concentrically arranged with the crankshaft of the combustion motor.

In addition an output member for forming the double crank gears is provided which extends between the resting second joint point and the free joint element, in which the output member is connected with the coupling element. If the tension means roller is rotated, the distance of the joint element on the tension means roller to the second joint point on the roller holder element changes. As a result, the angle between the longitudinal extent of the coupling member and the longitudinal extent of the output member changes. Consequently the distance of the free joint element to the axis of rotation changes through the rotating movement of the tension means roller. In this way it is possible for the rotating movement of the tension means roller to be picked up by the entrainment means and angle displacement can take place between rotation angle of the joint element about the axis of rotation relative to the rotation angle of the tension means roller about the axis of rotation. Therefore the smaller the selected length of the coupling element, the greater the angle displacement becomes.

As a further advantage the entrainment means can be coupled to the free joint element. If two double crank gears are envisaged, the entrainment means can have two locking hooks into each of which a joint element of a double crank gears engages. In this way the required kinematics are created in the active connection between the tension means roller and the entrainment means in order to attenuate the periodic torque of the entrainment means in the transmission to the tension means roller, and it is also achieved that the tension means roller has to be turned by a maximum of 180° about the axis of rotation until the active connection between the tension means roller and the entrainment means engages.

More particularly it can be envisaged that the free joint element of the first the double crank gear is arranged around 180° opposite the free joint element of the second double crank gears.

As a further advantage the entrainment means can have an axis of rotation whereby the second joint point lies in the axis of rotation of the entrainment means.

The objective of the present invention is also achieve by a power tool with a starter for starting a combustion motor of the power tools, whereby the starter has rotating tension means roller on which a tension means can be wound and which via an active connection is connected to an entrainment means of the combustion motor in order to introduce a rotating movement into the combustion motor, whereby in accordance with the invention it is envisaged that the active connection between the tension means roller and the entrainment means has at least one double crank gear. The above examples of embodiment and advantage of the starter can be used in the same way for the power tool.

BRIEF DESCRIPTION OF THE DRAWINGS

Further measures that improve the invention are set out below in more detail together with the description of a preferred example of embodiment of the invention with the aid of the figures. In these:

FIG. **1** shows perspective view of an example of embodiment of a starter for a power tool with the features of the present invention,

FIG. **2** shows a schematic view of a double crank gear that has the starter in accordance with the invention and

FIG. **3** shows a diagram in which the angle of rotation of the output member is shown in relation to the rotation of the tension means roller over the crank angle.

PREFERRED EXAMPLE OF EMBODIMENT OF THE INVENTION

FIG. **1** shows a perspective view of a starter **100** for starting a combustion motor, as used, for example, for a power tool **26** such as chainsaw, a lawnmower, a grass trimmer, a cutting grinder or suchlike. The starter **100** has a rotating tension means roller **10** onto which a tension means **11** can be wound, and on the end of the tension means **11**, shown for example as a pull cable, a grip **25** is provided. If an operator holds the grip **25** and introduces a tensile force into the tensions means **11**,

the tension means roller **10** is made to rotate. The rotational movement of the tension means roller **10** is transmitted via an active connection to an entrainment means, also referred to as an entrainment **27**, and the entrainment means is connected to the combustion motor in order to introduce a rotating movement into the combustion motor. For this the entrainment is connected with the crankshaft of the combustion motor, whereby the active connection between the tension means roller **10** and the entrainment means is only in place for the starting phase of the combustion motor.

The active connection between the tension means roller **10** and the entrainment means is formed by two double crank gears **12** and **13**. The tension means roller **10** has a flat side **14**, and the double crank gears **12** and **13** are arranged on the flat side **14** of the tension means roller **10**. The double crank gears **12** and **13** are arranged on the flat side of the tension means roller **10** in a position offset by 180° with regard to each other.

The tension means roller **10** is rotatably held in an axis of rotation **16** on a roller holder element **15**. The axis of rotation **16** coincides with the central axis of the roller holder element **15**. The roller holder element **15** is firmly integrated into the structure of the power tools so that the tension means roller **10** can be rotated about the fixed axis of rotation. With regard to the double crank gear **12** and **13** the das roller holder element **15** with the fixed axis of rotation **16** forms a first resting joint point **17** for both double crank gears **12** and **13**, so that the first joint point **17** coincides for both double crank gears **12** and **13**. Through the rotatability of the tension means roller **10** about the axis of rotation **16** the tension means roller **10** forms an output member **18** both for the first double crank gear **12** as well as for the second double crank gear **13**. The drive elements **18** of both double crank gears **12**, **13** are shown in dashed form as imaginary drive elements **18** and extend in a joint axis, so that the relevant drive elements **18** of the double crank gears **12** and **13** extend in the opposite direction from the axis of rotation **16**.

On the tension means roller **10** on the outside of the flat side **14** and therefore at a distance from the axis of rotation **16** two joint elements **19** are arranged, which are in a position 180° opposite each other in relation to the axis of rotation **16**. On rotation of the tension means roller **10** the joint elements **19** therefore rotate about the axis of rotation **16**. The joint elements **19** are in the form of pegs or bolts and are firmly arranged on the flat side **14** of the tension means roller **10**.

Each of the double crank gears **12** and **13** has a coupling element **20** which is held with a first end in a rotatable manner or the associated joint element **19**.

The roller holder element **15** also has a second resting joint point **21**, which serves as a resting joint point for both double crank gears **12** and **13**, and whereby the resting joint point **21** is arranged at a distance from the axis of rotation **16** in the roller holder element **15**.

At the resting, second joint point **21** one output member **22** is rotatably arranged for the first double crank gear **12** and one for the second double crank gear **13** whereby the second resting joint point **21** can also be in the form of a bolt or peg which extends from the face surface of the roller holder element **15**. Both drive elements are thus rotatably arranged with a first end on the second joint point **21**. In order to guarantee the function of the double crank gear **12** the second joint point **21** coincides with the crankshaft of the combustion motor.

Between the free, second end of the relevant drive element **22** in a joint element **23** the free side of the drive element **22** is connected in an articulated manner so that the drive elements **22** are connected to the coupling elements **20**.

If the tension means roller **10** is rotated, rotation about the axis of rotation **16** takes place, which forms the first joint point **17** of both double crank gears **12** and **13**. At a distance from the first joint point **17** the second joint point **21** is also arranged in a fixed manner on the roller holder element **15**, and on rotation of the joint element **19** on the tension means roller **10** about the first joint point **17**, the angle between the longitudinal extent of the coupling element **20** and the longitudinal extent of the output member **22** changes. In this way, depending on rotation angle of the tension means roller **10** about the axis of rotation **16**, the distance between the joint element **23** and the axis of rotation **16** increases and decrease so that angle-independent torque transmission from the tension means roller **10** to the entrainment means can take place.

The joint elements **23** are designed a drive lugs and in a manner which is not shown in more detail latches can be provided on the entrainment means through which the joint elements **23** can be individually caught. If the joint element **23** is turned about the axis of rotation **16**, a maximum rotation of around 180° is required for engaging with the latch of the entrainment means. The final active connection to the entrainment means is thus made possible via the joint element **23**, in that the coupling element **20** is connected with the output member **22** of the relevant double crank gear **12** and **13**. If the joint element **23** has just slipped by on the pole wheel latch, in the most unfavourable case a rotation of more than 180° may be necessary, whereby this drawback greater rotation being required can also occur when using only one double crank gear **12** or **13**.

In this way, on the basis of simple mechanics, a smoothing out of the torque progression in the tension roller means **10** can take place via rotation of the entrainment means which is connected with the crankshaft of the combustion motor and into which the rotation angle-dependent torque is transmitted. If the piston of the combustion motor is in the compression phase, the distance of the joint element **23** from the axis of rotation **16** can be particularly small, so that a high toque can be transmitted to the entrainment means. If the piston is in the decompression phase of the combustion motor, via the corresponding angle element the distance of the joint element **23** from the axis of rotation can be correspondingly large.

FIG. **2** shows a schematic view of the double crank gear **12**, **13**, whereby the elements of the double crank gears **12**, **13** are shown in a schematically abstracted manner. The roller holder element **15** is in the form of two spatially separated fixed bearings, whereby the bearings are fixed in the power tool. On the right the axis of rotation **16** in the roller holder element **15** is shown which forms the first joint point **17** of the double crank gears **12**, **13**. The fixed nearing on the left shows the second joint point **21** in the roller holder element **15**, through which the axis of rotation **16** of the output member **22**, **22'** is formed.

In a first position the double crank gear **12**, **13** with the drive element **18'**, the coupling element **20'** and the output member **22'** is shown in dashed form and after rotation of the output member **22'** about rotation angle Ψ the drive element **18'** is in the position of the drive element **18** shown in bold. The coupling element **20'** moves into the position of the coupling element **20** shown in bold and the output member **22'** moves into the position **22** shown in bold whereby the output member **22'** rotates about rotation angle ϕ.

The joint element **23** performs a circular movement about the second joint point and it can be seen that, for example, in position D**1** between the axis of rotation **16** and the imaginary path curve of the joint element **23**, the distance D**1** is considerable smaller than the distance D**2** when the elements of the double crank gears **12**, **13** are close to the position shown in a dashed manner.

As a result, by way of the arrangement in accordance with the invention of two double crank gears **12** and **13** a simple active connection between the tension means roller **10** and the entrainment means of the combustion motor of the power tool can be created, and via rotation angle ψ the distance between the joint element **23**, **23'** and the axis of rotation **16** can be greatly altered. Consequently, through full rotation of the tension means roller **10** the transmittable torque can be adjusted depending on the rotation angle of the compression behaviour of the piston in the cylinder so that a harmonic, even force is achieved over the entire tensile movement in the tension means **11**.

In FIG. **3** a diagram is shown of the course of the rotation angle ψ in relation to the rotation angle ϕ of the drive element to the output member via the crank angle 360°. It is clear that just before the lower dead point, at around 145°, the quotient of the rotation angles ψ/ϕ differs sharply depending on the length L of the coupling element **20**, whereby the shorter the selected coupling element **20**, the greater the quotient of the rotation angles ψ/ϕ becomes.

The invention is not restricted to the above preferred examples of embodiment. Rather, a number of variations are conceivable which make use of the described solutions, even in fundamentally different designs. All features and/or advantages, including structural details or spatial arrangements set out in the claims, the description or the drawings can be essential to the invention individually or in the most varied of combinations.

LIST OF REFERENCES

100 Starter
10 Tension means roller
11 Tension means
12 Double crank gear
13 Double crank gear
14 Flat side
15 Roller holder element
16 Axis of rotation
17 First joint point
18, **18'** Drive element
19 Joint element
20, **20'** Coupling element
21 Second joint point
22, **22'** Output member
23, **23'** Joint element
24 Axis of rotation
25 Grip
26 Power tool
27 Entrainment
L Length of the coupling element
ψ' Rotation angle of the drive element about the first joint point
ϕ Rotation angle of element about the second joint point
D1 First smaller distance
D2 Second larger distance

What is claimed is:

1. A starter for starting a combustion motor, with a rotating tension roller, onto which a tensioner can be wound and which, via active connection, is connected to an entrainment of the combustion motor in order to introduce a rotating movement into the combustion motor, wherein the active connection has at least one double crank gear between the tension roller and the entrainment, wherein

the starter is configured to provide the active connection after considerably less than a full rotation of the tension roller.

2. The starter in accordance with claim **1**, wherein the active connection has a least two double crank gears between the tension roller and the entrainment.

3. The starter in accordance with claim **1**, wherein the tension roller has a flat side, whereby the at least one double crank gear is arranged on the flat side of the tension roller.

4. The starter in accordance with claim **1**, wherein the at least one double crank gear having two double crank gears arranged in a position offset by 180° with regard to each other on flat side of the tension roller, whereby, in an arrangement of the several double crank gears, an even distribution over the circumference of the tension roller is provided.

5. The starter in accordance with claim **1**, wherein a roller holder with an axis of rotation is provided, on which the tension roller is held rotatably about the axis of rotation, whereby the roller holder provides a resting first joint point of the at least one double crank gear which lies on the axis of rotation.

6. The starter in accordance with claim **5**, wherein the tension roller comprises a drive element of the at least one double crank gear, whereby on the tension roller at a distance from the axis of rotation, at least one joint element is provided, and a first end of a coupling element of the double crank gear is arranged on the at least one joint element in an articulated manner.

7. The starter in accordance with claim **5**, wherein the roller holder has a resting second joint point of the at least one double crank gear which is provided at a distance from the axis of rotation of the tension roller.

8. The starter in accordance with claim **7**, wherein at least one output member is provided which extends between the resting second joint point and a free joint element, and the output member is connected to the coupling element.

9. The starter in accordance with claim **8**, wherein the entrainment is connectable to the free joint element.

10. The starter in accordance with claim **8**, wherein the free joint element of a first double crank gear of the at least one double crank gear is arranged 180° opposite a second free joint element of a second double crank gear of the at least one double crank gear.

11. The starter in accordance with claim **7**, wherein the entrainment has an axis of rotation whereby the second joint point lies in the axis of rotation of the entrainment.

12. A power tool with a starter for starting a combustion motor of the power tool, whereby the starter has a rotating tension roller onto which a tensioner can be wound and which, via an active connection, is connected with an entrainment of the combustion motor in order to introduce a rotating movement into the combustion motor, wherein the active connection between the tension roller and the entrainment has at least one double crank gear, wherein

the starter is configured to provide the active connection after considerably less than a full rotation of the tension roller.

13. A power tool with a starter in accordance with claim **1**.

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